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AUTHOR Speece, Deborah L.; McKinney, James D.
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ABSTRACT

A longitudinal investigation was conducted on the development of conservation skills in learning disabled (LD) children. During each of 3 years, six measures of conservation from the Concept Assessment Kit (space, number, substance, weight, continuous quantity, and discontinuous quantity) were administered to 31 newly identified LD students and 33 normally achieving children. Results indicated that the LD group demonstrated a developmental delay in attaining the stage of concrete operations. However, when this stage was achieved, the LD group appeared to acquire specific concepts at the same rate as normally achieving children. Academic achievement was not predicted by full scale IQ and total conservation scores in the LD group. The LD group exhibited a nonsignificant pattern of correlations between conservation performance and IQ and achievement variables, whereas the normally achieving group demonstrated moderate significant relationships. For the LD group, the lack of overlap between conservation performance, IQ, and achievement suggested that these children may be developmentally different in their approach to cognitive tasks. (Author/RH)

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The Longitudinal Development of Conservation Skills in Learning Disabled Children

Deborah L. Speece and James D. McKinney

Frank Porter Graham Child Development Center
University of North Carolina at Chapel Hill
Highway 54 Bypass West 071A
Chapel Hill, North Carolina 27514

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ABSTRACT

A three year longitudinal investigation was conducted on the development of conservation skills in learning disabled (LD) children. Six measures of conservation (space, number, substance, weight, continuous and discontinuous quantity) from the Concept Assessment Kit were administered to 31 newly identified learning disabled students and 33 normally achieving children during each of three years. Results indicated that the learning disabled group demonstrated a developmental delay in attaining the stage of concrete operations. However, when this stage was achieved, the LD group appeared to acquire specific concepts at the same rate as normally achieving children. Academic achievement was not predicted by Full Scale IQ and Total Conservation scores in the learning disabled group. The LD group exhibited a nonsignificant pattern of correlations between conservation performance and IQ and achievement variables whereas the normally achieving group demonstrated moderate, significant relationships. For the LD group, the lack of overlap between conservation performance, IQ, and achievement suggested that these children may be developmentally different in their approach to cognitive tasks.

The Longitudinal Development of Conservation Skills in Learning Disabled Children

Learning disabilities is one of the least understood developmental phenomenon in the field of exceptional child development. Although definitions of this handicapping condition vary, learning disabled children display average to above average intelligence but exhibit subaverage academic achievement. This disparity between intellectual competence and academic performance is usually explained by specific deficits in a variety of cognitive processes (Gibson, 1965; Johnson & Myklebust, 1967; Toregsen & Kail, 1980; Vellutino, 1977). Notably absent from most conceptual and empirical work with learning disabilities is a developmental perspective on cognitive functioning. The field has been dominated by psychometric perspectives to the exclusion of a more qualitatively oriented position. Following Elkind (1980), it appeared necessary to compliment the psychometric or "trait" assessment with a Piagetian or "forms" approach which could tap the child's conceptual organization. Whereas psychometric intelligence is a static concept not amenable to a developmental analysis, attainment of different conceptual levels is based on development and may provide further insights to the intelligence - achievement disparity experienced by LD children.

The present investigation addressed three important questions in the cognitive funcitoning of learning disabled children: a) Do LD children experience a developmental lag in attaining the stage of concrete operations when compared with normally achieving children?; b) Do LD children have differential difficulty with specific conservation tasks when compared with NLD children?; and c) Is the performance of LD children on conservation tasks predictive of school acheivement independent of psychometric intelligence?

The first question addressed by this study concerns whether or not learning disabled children experience a delay in attaining the concrete operational stage of development. Although the pattern of cognitive development for mentally retarded children is well known in that the rate of progress through cognitive developmental stages is slower than for children of normal intelligence and characterized by a developmental ceiling (Inhelder, 1966; Wilton & Boersma, 1974), there is no comparable longitudinal research with LD children. The avaliable evidence is equivocal. Two studies that compared learning disabled and normally achieving nine year old children on conservation tasks found that the two groups did not differ (Meltzer, 1978; Fincham, 1979). On the other hand, Klees and Lebrun (1972) reported a one year delay in the acquisition of concrete operations in a cross sectional study of dyslexic children, ages 7 to 11. There remains, then, the question of whether learning disabled children display a developmental lag attaining concrete operations.

The second question we studied pertained to horizontal declage. According to cognitive developmental theory, children may show individual differences in the order of success in passing conservation tasks since they conceptualize experiences differently. Therefore, it is psychologically and educationally relevant to determine the age at which LD children acquire specific concepts as compared to NLD children. The literature on normally achieving children suggests that the conservation tasks used in the present study (number, discontinuous quantity, continuous quantity, space, substance, and weight) are not well differentiated in terms of difficulty (Goldschmid, 1967; Goldschmid & Bentler, 1978). In terms of order of acquisition, there is evidence to suggest that substance conservation precedes weight (Smedslund, 1961; Elkind, 1961b; Goldschmid, 1967) and discontinous quantity precedes

continuous quantity (Elkind, 1961a). Wilton & Boersma (1974) suggested that number and discontinuous quantity are generally conserved between the ages of 6 and 7 years in normal samples, followed by continuous quantity, space, and substance between 7 and 8 years of age with weight being conserved between 8 and 9 years of age.

There is limited evidence concerning order and horizontal decalage in LD samples. Meltzer (1978) reported that LD and NLD children were similar on the rank order of conservation task difficulty as calculated from the percentage of children passing each task. The longitudinal question to be asked of the present data is whether or not LD children successfully pass individual conservation tasks at the same age as their normally achieving peers. Whereas the first research question concerns overall group differences in attaining concrete operations, the second question provides a more detailed analysis of learning disabled children's cognitive functioning. For example, LD children may acquire conservation of discontinuous quantity (beads) at the same age as NLD children but attain conservation of continuous quantity (liquid) six months later than NLD children. Such a finding would imply that LD children have greater difficulty in making the transition from quantities that can be broken into physical units to quantities that require primarily mental manipulation.

The final question of interest concerns the relationship between LD children's level of logical thinking and academic achievement. Correlational studies with normal samples have shown moderate, positive relationships between conservation and academic subjects such as reading recognition and arithmetic as well as with measures of IQ (Elkind, Horn, & Schneider, 1965; Goldschmid, 1967; Goldschmid & Bentler, 1968). Of interest with the learning disabled sample is the degree to which the children's level of reasoning is

predictive of academic achievement independent of the contribution of IQ. This type of analysis can potentially enrich current assessment practices in learning disabilities by providing a process oriented approach to compliment the traditional psychometric perspective.

For example, Elkind and his associates (Elkind Horn, & Schneider, 1965; Elkind, Larson & Van Doorninck, 1965) demonstrated the importance of decentration in relationship to reading achievement. In a perceptual decentration training experiment with slow reader Elkind, Larson, and Van Doorninck, (1965) concluded that the mental operation of manipulating perceptual symbols (letters) was an important ability in reading achievement. If learning disabled children experience a delay in attaining concrete operations which are dependent on the ability to decenter, then this may assist in explaining subpar academic achievement.

Method

Subjects

The subjects for this study were 31 LD and 33 NLD children from the same first and second grade classrooms. These children were from an original longitudinal sample of 75 children and represented those children who had complete conservation data for all three years of the study. The LD children were newly identified by licensed school psychologists as needing special education services according to state and federal guidelines for LD programs. These rules included intelligence within the normal range and at least a 6 month grade discrepancy in one achievement area.

The comparison group of NLD children were randomly selected from teacher prepared lists of normally achieving children of the same sex and race as the LD children. Normal progress and intelligence was verified by administration

of the Reading Recognition, Reading Comprehension, and Mathematics subtests of the Peabody Individual Achievement Test (PIAT) and the Wechsler Intelligence Test for Children-Revised (WISC-R) by the research staff. Table 1 presents subject characteristics on demographic, achievement, and aptitude variables. Although both groups obtained mean scores in the normal range for both achievement and intelligence, separate Group MANOVAs for the PIAT and WISC-R subtests indicated significant group differences (PIAT $F(1,62) = 38.63$, $p < .01$; WISC-R $F(1,60) = 18.58$, $p < .01$. With the exception of WISC-R Verbal IQ ($F(1, 60) = 3.44$, $p < .06$), all univariate tests were significant beyond the $p = .01$ level.

Insert Table 1 About Here

To provide a more sensitive analysis of possible developmental differences, each group of children was divided into two age cohorts of six and seven year olds according to their age at the school system's cut off date for school entrance. Within the LD sample there were 19 six year olds (LD-YOUNG), mean age = 80.6 months, SD = 3.4 and 12 seven year olds (LD-OLD), mean age = 93.9 months, SD = 4.0. The comparison group had 18 six year olds (NLD-YOUNG), mean age = 83.3 months, SD = 4.5 and 15 seven year olds (NLD-OLD), mean age = 89.7 months, SD = 8.3.

Conservation Measures

Each child was administered the six conservation tasks (space, number, substance, weight, continuous and discontinuous quantity) from the Concept Assessment Kit - Conservation, Form A (Goldschmid & Bentler, 1968) during each of three years as part of a larger battery of tests. The Concept Assessment

Kit (CAK) is a standardized test for assessing Piagetian conservation concepts. A three point scoring system (0,1,2) was used for each task resulting in a maximum conservation score of 12 points for each year. To receive a score of 2 points, the child had to judge that two objects still had the same quantity after one object was transformed by the experimenter as well as give an adequate explanation for the judgement. A score of 1 point indicated a correct judgement but not an acceptable explanation while a score of 0 indicated neither (non-conserver). An adequate explanation reflected either the notion of invariant quantity, compensation, or reversibility. In addition to the Concept Assessment Kit, all children were administered the Reading Recognition, Reading Comprehension, and Mathematics subtests of the PIAT during each of the three years.

Data Analysis

To address the first research question concerning group differences in attaining the stage of concrete operations, a Group (LD, NLD) x AGECODE (Young,Old) x YEAR (1,2,3) MANOVA was conducted on the total conservation scores. The MANOVA strategy for repeated measures in longitudinal studies outlined by McCall and Appelbaum (1973) was employed to account for correlations among repeated measures. The contribution of conservation skills in predicting school achievement was assessed by employing a backward elimination regression technique in which Total Conservation Scores for LD children and Full Scale WISCR-IQ were used as criterion variables to predict PIAT Reading Recognition, Reading Comprehension, and Mathematics residual gain scores. The backward elimination technique first assesses the proportion of achievement variance accounted for by all three predictors (Full Model) and then successively eliminates variables that do not account for a significant

amount of variance ($p = .10$). The Final Model of significant variables is only interpreted if the Full Model is significant at $p < .05$ level. In addition to predicting achievement across years (year 1 to year 2 and year 3; year 2 to year 3), concurrent regressions were conducted using PIAT subtest raw scores as the dependent measures.

A probit analysis was used to estimate the age at which 75% of the children in each group attained conservation (score of 2 points) on each of the six tasks. This approach is most often used in biological assay research where the research question concerns the amount of a stimulus needed (dosage) to produce a specified response in an organism (Finney, 1978). In the present study, "dosage" is years of experience and the specified response is the percentage of children who attain conservation at a particular age level. A variation of this technique has been suggested for use in longitudinal studies (Landis & Koch, 1979) but there is an important caution to be considered in interpretation of the present data. Ironically, the best design to handle the issue of horizontal decalage between groups would be a cross sectional approach in order to obtain a number of different subjects at each age level. Since the present design is longitudinal, several of the younger subjects were counted three times in the various age levels created to parallel different dosage levels. This lack of independence among subjects violates an assumption for the chi-square statistic used, in probit analyses, to assess goodness of fit between the data and the probit model. The results of the analysis, then, are best described as exploratory in nature in determining the usefullness of pursuing the issues of order and decalage in future research.

With this caution in mind, nine age levels were created for 72 to 125 months at 6 month intervals. For each task and each group, the number of subjects who fell into each group across the three years of the study was counted as was the number of subjects who obtained a score of 2 points for each task. The probit analysis essentially is a type of regression of response (conserver) on dose (age) and provides an estimate of the dosage required for 75% of the children to attain conservation on each task (Finney, 1978). Although any percentage level could have been chosen, the 75% level was selected as it conforms to the standard used by Piaget in determining stage transitions and by Elkind (1961b) in assessing various conservation acquisitions. The age levels obtained will be used descriptively to compare the learning disabled children with the normally achieving group in terms of order of acquisition and extent of horizontal decalage.

Results

Group Differences

The Group x Agecode x Year MANOVA resulted in a significant main effect for Group ($F_{1,60} = 15.19$, $p < .0002$) and a significant Agecode x Year interaction ($F_{2,120} = 4.93$, $p < .008$) with a linear trend for the interaction ($F_{1,60} = 7.19$, $p < .009$). Figure 1 graphically displays these results. The interaction appeared to be due to the low conservation scores of the LD-6 year old group in the first year of the study. Separate Group x Agecode ANOVAs for each year confirmed this interpretation. Although group membership was a significant factor for each of the three years (all p's $< .01$), Agecode was significant only at year 1 ($F_{1,60} = 6.84$, $p < .01$). None of the agecode interactions in subsequent years was significant. As Figure 1 shows, the younger LD children improved their performance by the second year but the LD

group as a whole continued to lag behind their normally achieving peers at year 3.

Insert Figure 1 about here

Order of Acquisition and Horizontal Decalage

The probit analysis provided estimates of the ages at which the LD and NLD groups acquired conservation concepts. Table 2 displays this information which supports a developmental delay in LD children as suggested by the previous analyses and a visual inspection of Figure 1. Although it is inappropriate to place a great deal of confidence in the age estimates, the results indicated an approximate 1 1/2 to 2 year delay for LD children in acquiring specific concepts.

Insert Table 2 about here

Within the two groups, acquisition of concepts appeared to follow the order suggested by previous literature in that substance proceded weight and discontinuous quantity preceded continuous quantity. Comparison of the two groups indicated a different order for LD and NLD children. For both groups, space and weight were the beginning and end points with the LD group conserving number, substance, discontinuous and continuous quantity in that order. The NLD group first conserved discontinuous quantity followed by continuous quantity, substance, and number.

The late development of number conservation in the NLD children was a curious result and prompted an inspection of the percentage of conservers at

each of the created age levels. All NLD children in the 6-7 year age levels conserved number but the percentages at the later age levels varied from 92% to 40%. That there was not a consistent increase in the percentage of number conservers with age runs counter to cognitive-developmental theory. Since the other tasks for either group did not show this trend, we suspected that age for number was a spurious result in the NLD group.

The most striking aspect of this analysis concerns horizontal decalage. Although the LD group appeared to encounter a delay in entering the stage of concrete operations, it appeared that they attained the specific concepts rapidly between the ages of 8 and 10 years. The longest lag was 14 months and occurred between number and substance. This description also fits the NLD data discounting number conservation. The normally achieving group also attained specific concepts during a 2 year period albeit two years earlier than the LD group. The longest lag was 17 months between space and discontinuous quantity.

Prediction of Academic Achievement

Multiple regression analyses were used to test the independent contribution of conservation performance to academic achievement apart from Full Scale Intelligence. Both concurrent prediction and prediction across years were assessed. The within years analyses for each of the three achievement variables (reading recognition, reading comprehension, and mathematics) were nonsignificant in that the Full Model did not account for a significant amount of achievement variance. With the exception of reading comprehension, academic achievement was not predicted across years. Reading Comprehension was predicted by Total Conservation and Full Scale IQ from year 1 to year 2 ($F_{2,25} = 3.53$, $p < .05$, $R^2 = .22$). However, the Final Model

retained only Full Scale IQ as Total Conservation did not account for a significant amount of variance ($F\ 1,26 = 6.08$, $p < .02$, $R^2 = .19$).

Given this pattern of results, the intercorrelations of total conservation scores with achievement and aptitude variables within each group were examined. Table 3 presents the within-year correlations for these variables. The data for the normally achieving group were consistent with previous literature as the majority of correlations were moderate in magnitude and significant. The correlations for the learning disabled group, however, presented an entirely different pattern. For these children, all correlations were nonsignificant with several being in a negative direction. In comparison with the NLD sample, there was no overlap between conservation performance and achievement and intelligence in the LD group.

Insert Table 3 about here

Discussion

The results of this longitudinal investigation indicated that learning disabled children experienced a developmental delay in attaining the stage of concrete operations but when the transition from the preoperational to the concrete operational stage was achieved, they appeared to acquire specific concepts at the same rate as normally achieving children. The present data suggested that LD children did not "catch up" with their peers after three to four years of school experience. Although tentative, the results of the probit analyses indicated that the NLD and LD children may acquire conservation of weight at about the same age. The predicted age represented an extrapolation of the data and car only be interpreted as exploratory in

nature. Whether or not the developmental lag persists into the later elementary school years and adolescence is a question that needs to be addressed in future reseearch.

The academic consequences of the delayed achievement of the concrete operational stage of development are less clear. Conservation performance and Full Scale IQ, in concert, were neither predictive of concurrent achievement or residual gain scores for the LD group. The small n for the LD sample may have reduced the opportunity for significance in the multiple regression analyses. However, the pattern of correlations of total conservation scores with academic achievement and psychometric intelligence were extremely different for the LD and NLD groups which had essentially the same number of children in each. An explanation based on a possible restricted range of variable scores does not seem justified. The two groups were not significantly different on Verbal IQ but yet the NLD group obtained significant correlations between Total Conservation and Verbal IQ for each of the three years while the nonsignificant correlations for the LD group ranged from -.26 to .15. The complete lack of overlap between a Piagetian, qualitative assessment and a psychometric, quantitative assessment runs counter to previous research with both normal and mentally retarded subjects (Goldschmid, 1967; Wilton & Boersma, 1974). Although speculative, the lack of concordance between process and content assessments of intelligence may indicate that LD children are not only developmentally delayed but also developmentally different in their approach to cognitive tasks. We are currently rescoring the Conservation protocols in terms of the quality of explanation (after Elkind, 1961b) and in terms of nonconservers' choice of either the standard or manipulated object (after Goldschmid, 1967). Analyses

of group differences in these aspects of conservation acquisition may provide clues to differences in task orientation.

The major findings of this study emphasize the importance of viewing learning disabilities from a developmental perspective. Research results based on older samples within a limited age range may mask important differences that occur at earlier ages. Further research is needed to investigate not only the duration of developmental lags but also the reasons behind the cognitive immaturity of learning disabled children.

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Table 1

Subject Characteristics for Learning Disabled (LD)

and Normally Achieving (NLD) Children

		LD	NLD
N		31	33
RACE (%)	B	12 (38.7)	11 (33.3)
	W	19 (61.3)	22 (66.7)
SEX (%)	F	8 (25.8)	8 (24.2)
	M	23 (74.2)	25 (75.8)
AGE	M	85.8	86.3
	SD	7.5	7.2
MOTHER'S EDUCATION	M	11.8	12.6
	SD	2.1	2.1
PIAT SCORES			
Read. Rec.	M	91.9	103.1
	SD	8.2	10.7
Read. Comp.	M	95.5	102.5
	SD	7.1	10.6
Math	M	90.2	102.5
	SD	8.9	10.8
WISC-R			
Verbal	M	98.9	105.2
	SD	12.1	14.2
Performance	M	95.0	108.7
	SD	12.9	13.6
Full Scale	M	96.4	107.5
	SD	12.5	13.9

Table 2

Estimated Ages (Years-Months) at Which 75% of LD and NLD Children Acquired Conservation Concepts

	Space	Number	Substance	Discountinuous Quantity	Continuous Quantity	Weight
LD	8-10	9-1	10-3	10-7	10-10	11-4
NLD	6-4	9-3*	8-8	7-9	8-7	11-1

*See text for elaboration

Table 3

Concurrent Intercorrelations of WISC-R and PIAT Subtests with Total Conservation Scores (Total) for LD and NLD Children

	LD			NLD		
Total	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Reading Rec.	-.16	.22	.07	.28	.18	.17
Reading Comp.	-.30	.08	.19	.34*	.20	.35
Math	-.07	.09	.04	.37*	.28	.29
Verbal IQ	-.26	.15	-.13	.46**	.38*	.38*
Performance IQ	-.37	-.16	-.13	.36*	.36*	.30
Full Scale IQ	-.34	-.16	-.14	.48**	.42*	.37*

* $p < .05$

** $p < .01$

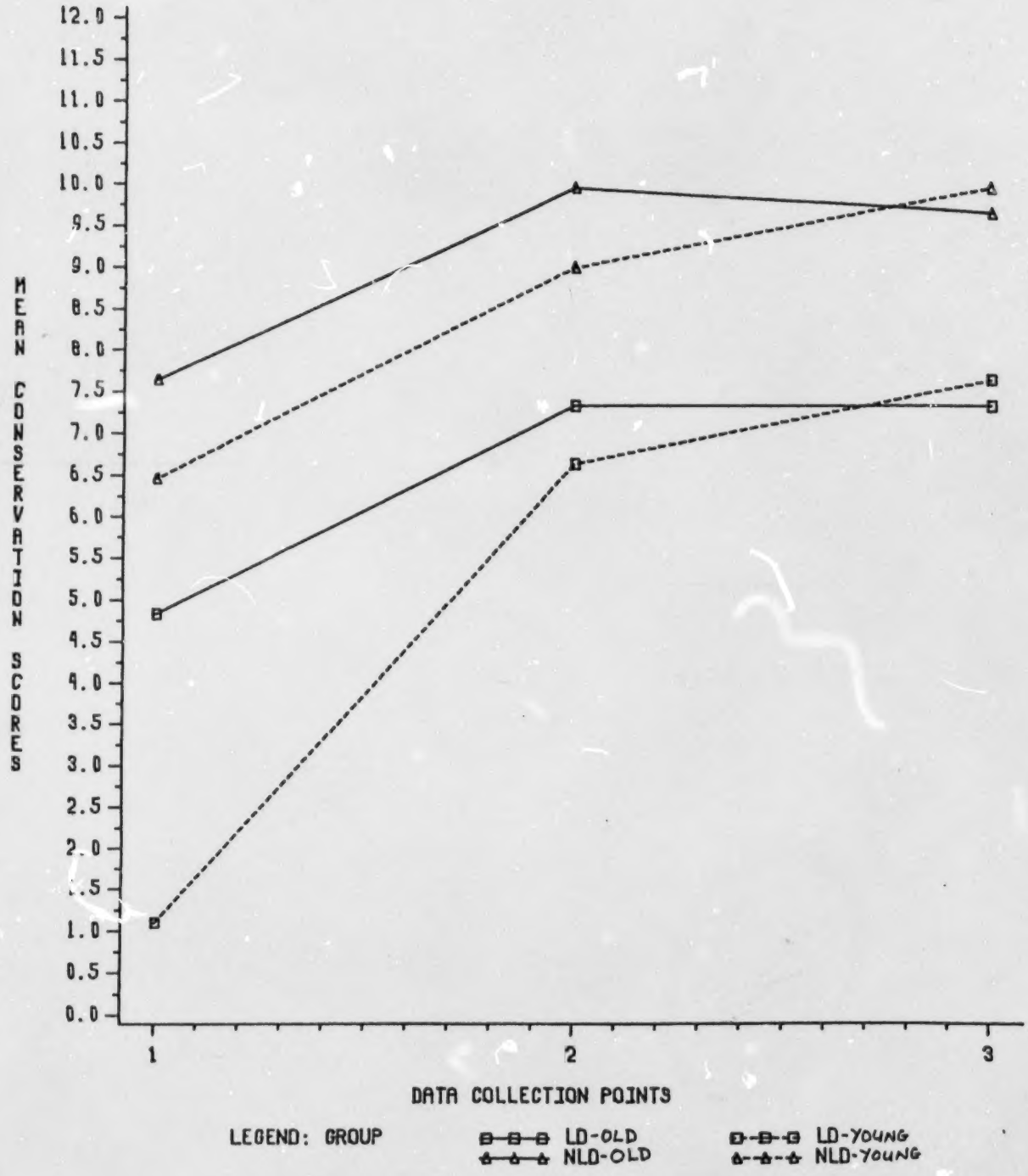

Figure 1. Mean conservation scores for 6 and 7 year old cohorts of LD and NLD children across three years